ABSTRACT

A method and apparatus that allows accurate spectrophotometric determination of the concentrations of various hemoglobin species in whole blood without hemolysis or dilution. To overcome the complex optical properties of whole blood, the invention employs 1) an optical apparatus designed to maximize the true optical absorbance of whole blood and to minimize the effects of light scattering on the spectrophotometric measurements of the concentrations of various constituent components, and 2) methods to correct the hemoglobin concentration measurements for light scattering and for the effects of the finite bandwidth of the substantially monochromatic light. In the optical apparatus (including an optical cuvette) all optical parameters, such as sample thickness, detector size and shape, sample-to-detector distance, wavelengths, monochromicity, and maximum angle of light capture by detector, are optimal values so as to minimize the contribution of light scattering to the total optical attenuation of unaltered whole blood and so as to maximize the contribution of true optical absorbance. After making measurements of a blood sample's optical density at each of the wavelengths, the invention makes corrections for the effects of light scattering by red blood cells, for light scattering produced by other causes, and (if necessary) for the effects of the finite bandwidth of the substantially monochromatic light.

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A method and apparatus which allow accurate spectrophotometric determinations of the concentrations of various hemoglobin species in whole blood without hemolysis or dilution. To overcome the complex optical properties of whole blood, the invention employs 1) an optical apparatus designed to maximize the true optical absorbance of whole blood and to minimize the effects of light scattering on the spectrophotometric measurements of the concentrations of various constituent components, and 2) methods to correct the hemoglobin concentration measurements for light scattering and for the effects of the finite bandwidth of the substantially monochromatic light. In the optical apparatus (including an optical cuvette) all optical parameters, such as sample thickness, detector size and shape, sample-to-detector distance, wavelengths, monochromicity, and maximum angle of light capture by detector, are optimal values so as to minimize the contribution of light scattering to the total optical attenuation of unaltered whole blood and so as to maximize the contribution of true optical absorbance. Four of the seven wavelengths of light are chosen by a criterion that minimizes the spectrophotometric error in the measurements of the concentrations of oxy-, carboxy-, and methemoglobin. Additional wavelengths enable the invention to assess light scattering quantitatively and to measure the concentrations of bilirubin and sulfhemoglobin. After making measurements of a blood sample's optical density at each of the wavelengths, the invention makes corrections for the effects of light scattering by red blood cells, for light scattering produced by other causes, and (if necessary) for the effects of the finite bandwidth of the substantially monochromatic light. By eliminating the need for hemolysis or dilution, the present invention overcomes disadvantages of prior art that requires pumps, plumbing, ultrasonic hemolyzers, and associated control circuitry, yet it

makes accurate spectrophotometric measurements of the bilirubin concentration, the total hemoglobin concentration, and the relative concentrations of oxy-, deoxy-, carboxy-, met-, and sulfhemoglobin. Because the sample is neither hemolyzed nor diluted, it can be subjected to further chemical or hematological analysis.

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